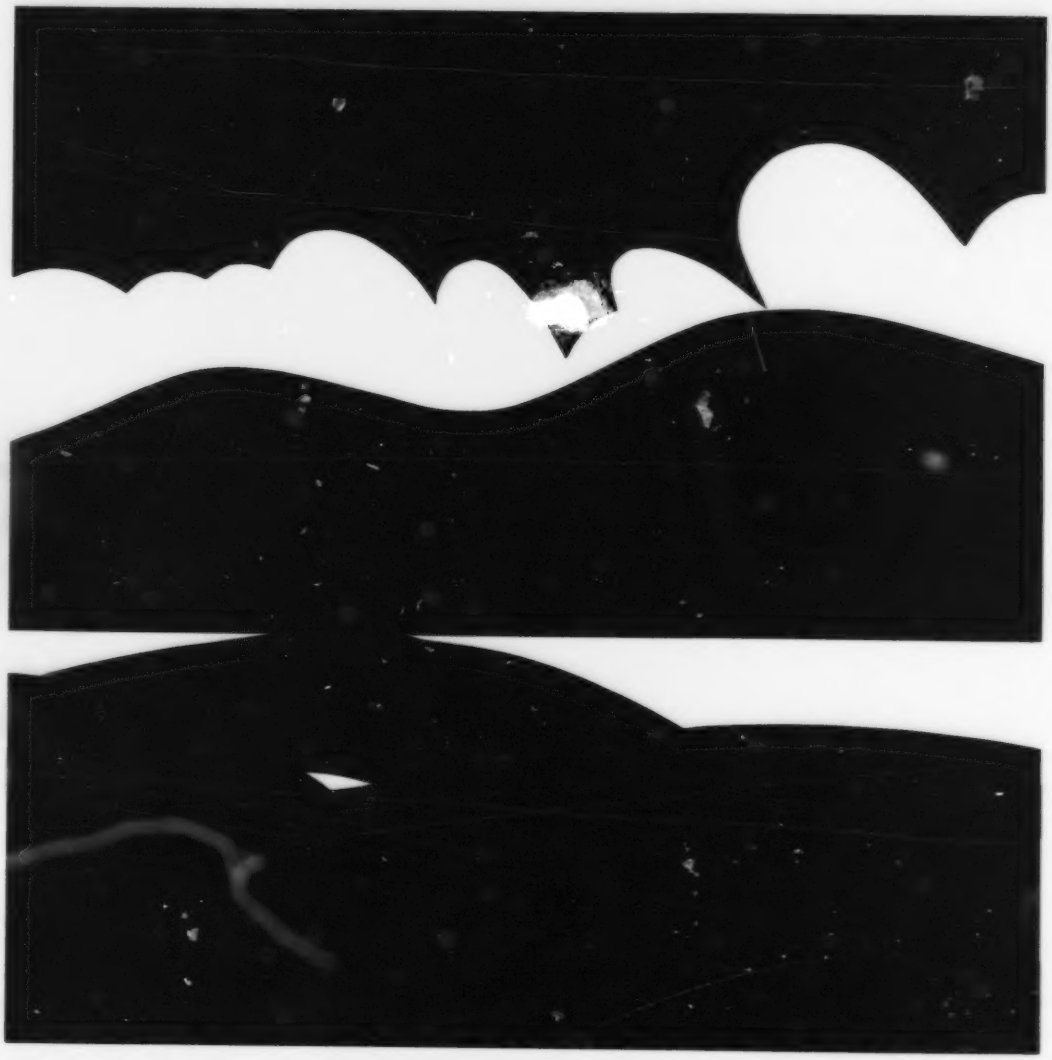
NAKAMUN LAKE



Alberta

ENVIRONMENT
Water Quality Control Branch
Pollution Control Division

89-05683/

Lakes attract people. And people want to know why "their" lake is the way it is — why is it so green in July? Is the water quality really deteriorating? How do our activities affect the lake?

This brochure, one of a series on Alberta's lakes, attempts to answer these questions by presenting findings of water quality studies conducted by the Water Quality Control Branch of Alberta Environment.

As you read through the brochure, you may find you have questions about the concepts and illustrations. At the end is a section called **Explanation of Lake Characteristics.** Refer to this for further interpretation.

Brochures are available for the following lakes:

Sandy Lake	Pine Lake	Lac La Biche
Lac La Nonne	Garner Lake	Nakamun Lake
Wizard Lake	Skeleton Lake	Wabamun Lake

JANUARY, 1985

Nakamun Lake is an interesting and attractive small lake located about 55 km northwest of Edmonton. It may be reached by turning east from Highway 33 about 3 km north of the Rich Valley school. There is public access and a boat launch at Nakamun Park on the south shore.

Physical Characteristics

As the depth contour map shows, Nakamun is fairly shallow, with the greatest depth (7.6 m or 25 feet) in the center of the lake. It has no major inflows — the small creeks entering the lake tend to dry up after snowmelt runoff in spring. The outflow creek, located on the western end of the lake, rarely flows. It is thought to connect with Lac La Nonne during periods of high runoff.

Fishing

Winter kills in Nakamun Lake have nearly eliminated sport fish populations. A few Northern Pike (jackfish) inhabit the lake — they probably enter the lake from Lac La Nonne or other areas. Sticklebacks and minnows are abundant. Winter kills occur about once in two or three years, usually when snow cover is heavy or when the lake does not mix thoroughly before ice cover forms.

Nutrient Sources

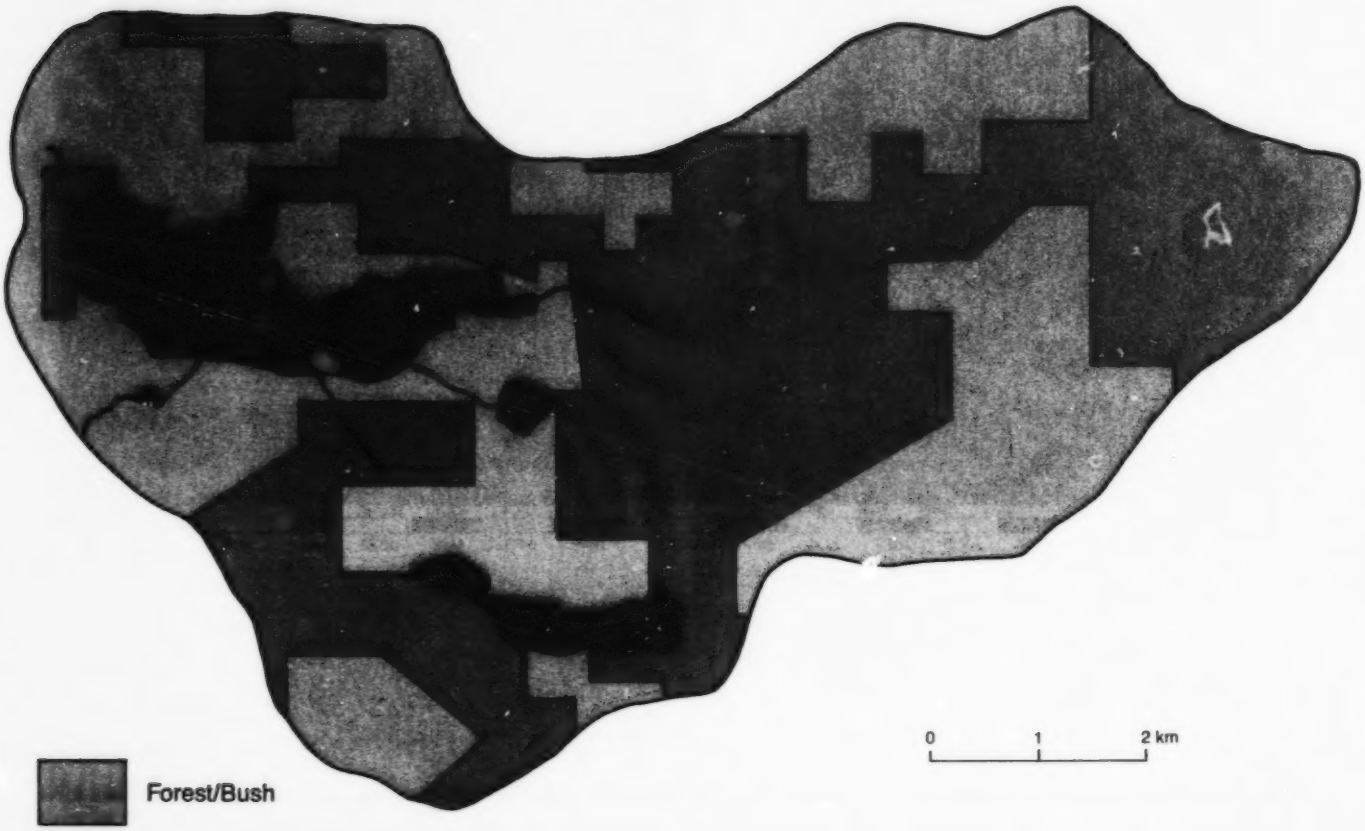
The watershed surrounding Nakamun Lake is large compared to the size of the lake (see Watershed Map). Much of it is in agriculture. Both of these factors suggest that the supply of nutrients to the lake would be large. According to the Theortetical Phosphorus Supply table, 70 per cent of the total estimated phosphorus supply comes from cleared land. Consequently, the areal loading figure — the amount of phosphorus entering a square metre of lake surface — is among the highest calculated for lakes studied by Alberta Environment. Thus, one would expect that Nakamun Lake would be very eutrophic, which of course it is.

However, it is unrealistic to think that the tiny inflow streams entering Nakamun Lake could carry nutrients from the distant parts of the watershed. But if the watershed isn't supplying large quantities of nutrients, then why is Nakamun Lake so eutrophic? The answer to this is related to oxygen conditions in the lake.

Depth Contour Map

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS		
LAKE AREA	km^2	3.16
DRAINAGE AREA (excluding lake)	km^2	54.88
DRAINAGE AREA/ LAKE VOLUME		5.
VOLUME	m^3	11.840×10^6
MAXIMUM DEPTH	m	7.6
MEAN DEPTH	m	3.8
INFLOW	m^3	4.303×10^6
RESIDENCE TIME	years	2.8

Nakamun Lake Watershed Map



Forest/Bush

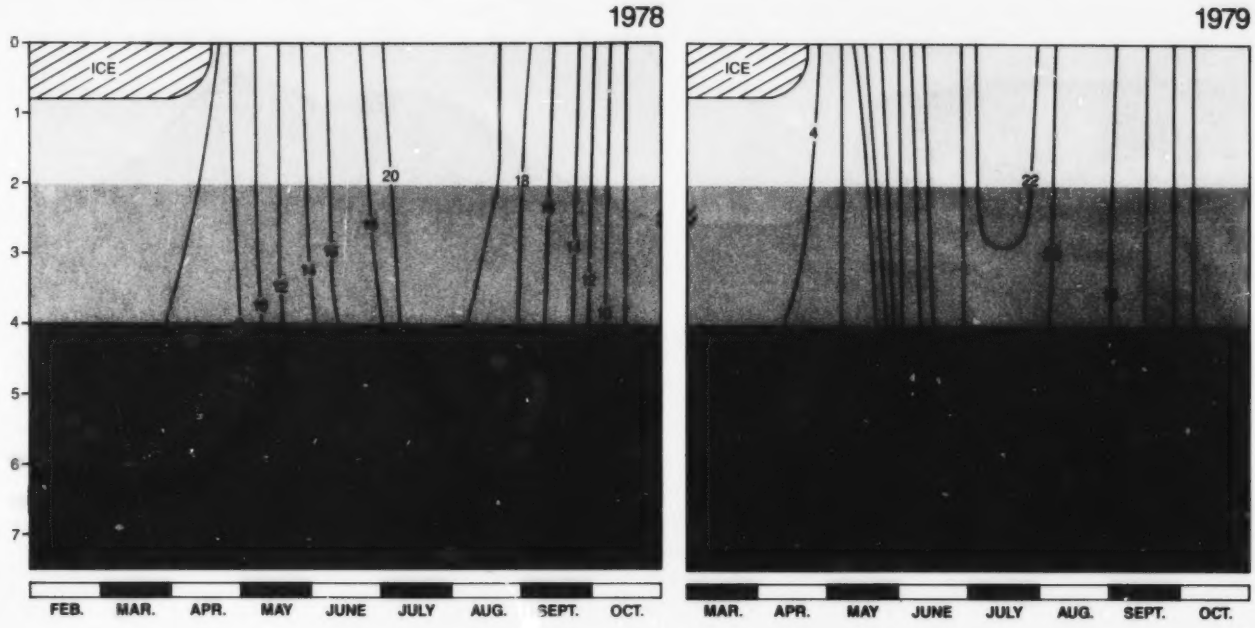
Urban/Cottage

Agricultural/Cleared

THEORETICAL PHOSPHORUS SUPPLY, kg/year

Surface Run-off:	
Forested/Bush	174.
Cleared/Agricultural	1,311.
Urban, Cottages	50.
Precipitation, Dustfall	94.
Flow from Upstream Lakes	82.
Sewage from all cottages and camps	175.
TOTAL	1,886.
Areal loading, g/m² of lake surface	0.597

Temperature (°C)

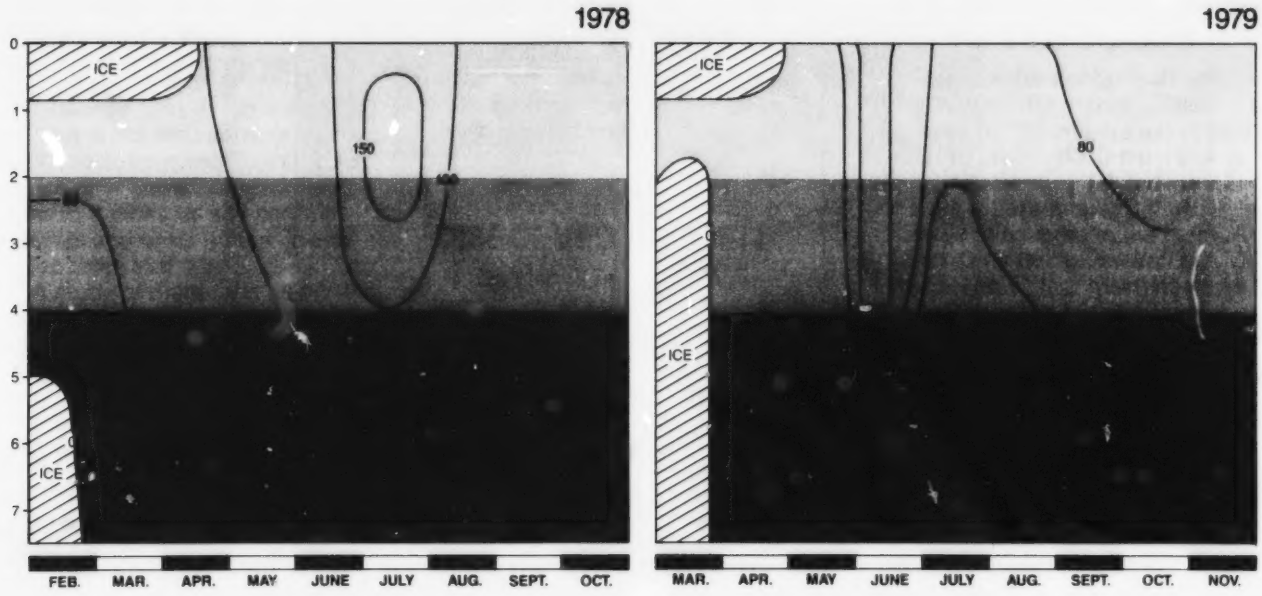


Temperature

The temperature graph indicates that Nakamun is a mixed lake. The lines running vertically show that the temperature was the same from the top of the lake to the bottom on any particular day. However, it is possible, as in July both years, for the surface water to warm faster than the water near the bottom.

See "EXPLANATION OF LAKE CHARACTERISTICS" at end of brochure for clarification of these graphs.

Dissolved Oxygen (% Saturation)



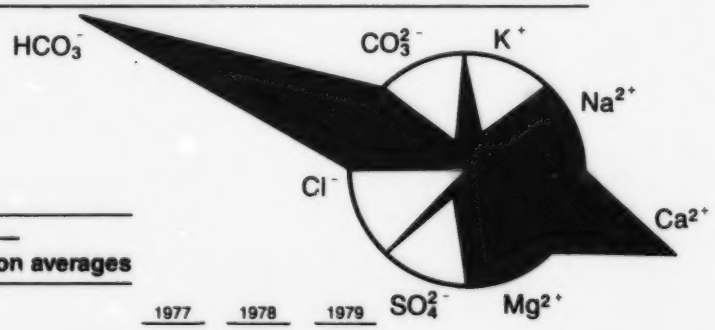
Oxygen

In spite of mixing on windy days, the bottom water in Nakamun Lake becomes very low in oxygen early in the summer. As the Dissolved Oxygen graph shows, there was a one-metre layer of water with less than 20% oxygen saturation above the mud. Chemical changes occur in the mud as a result of this loss of oxygen. Phosphorus that was chemically bound to mud particles when oxygen is high moves into the water and is carried up to growing algae, stimulating their growth. This phosphorus recycling effect maintains the highly eutrophic state of the lake. It is probably more important than the nutrient supply from the watershed and cottages.

Chemistry

Nakamun is a calcium-bicarbonate lake — these ions dominate the water chemistry. The salinity (saltiness) in Nakamun is fairly low, and well within the range favored by fish and other aquatic life.

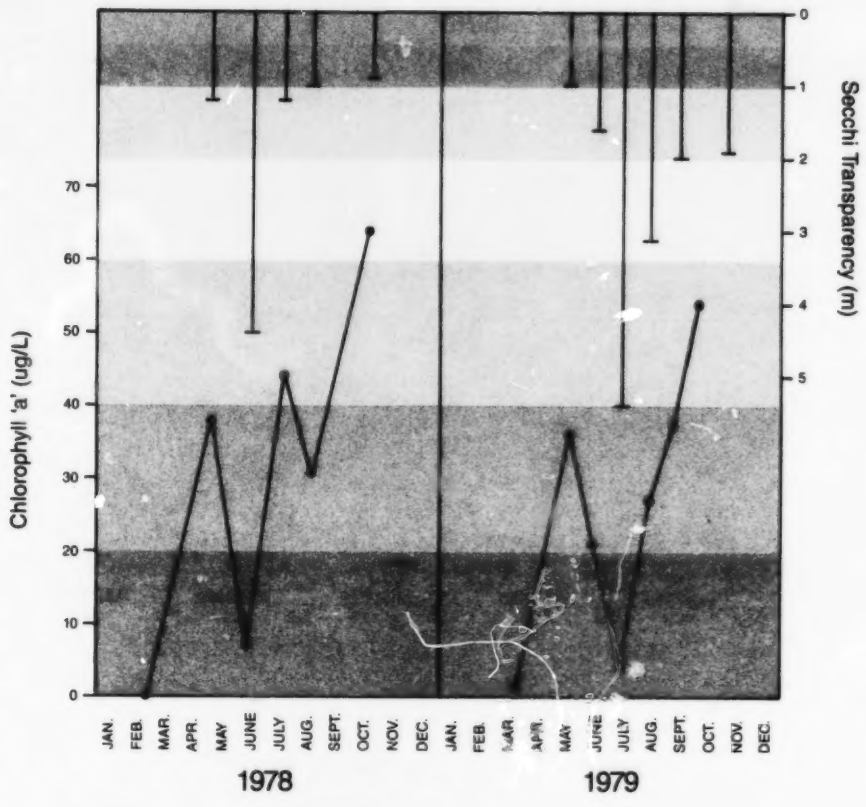
IONIC DIAGRAM — Relative proportions of ions 1977, 1978, 1979



CHEMISTRY — Ice free season averages

		1977	1978	1979
TOTAL SALINITY	meq/L	6.	6.	6.
pH (RANGE)		7.3 - 8.7	7.8 - 8.9	7.2 - 8.9
ALKALINITY	mg/L	141.	149.	141.
TOTAL DISSOLVED SOLIDS	mg/L	161.	166.	153.

Trophic Status



Algae and Trophic Status

Nakamun Lake undergoes dramatic changes in the amount of algae (chlorophyll) in the water over the summer, as the bottom graph above shows. After a peak in May, there was a decline to very low levels. At the same time the water was very clear, as the long lines on the Secchi transparency graph indicate. Anyone visiting the lake at this time would think that the lake has excellent water quality. This clarity is mainly a result of small animals called Daphnia consuming the algae. But after this, phosphorus is recycled from the bottom mud, stimulating the growth of blue-green algae, which by late summer turn the lake to 'pea soup'. This algae has the appearance of grass blades or globular masses — which unfortunately is not very good food for Daphnia, and they tend to disappear.

It seems likely that Nakamun Lake has become more eutrophic over the past fifty or so years, as evidenced by the increased frequency of winter fish kills. Because no one sampled the lake until recently, we don't know. But as parts of the watershed were cleared for agriculture, cottages or other uses, the quantity of phosphorus entering the lake undoubtedly increased. This may have triggered larger algal populations, which ultimately enhanced nutrient recycling from the bottom mud, leading to the lake's present highly eutrophic state.

Because Nakamun Lake is typical of many shallow, fertile lakes that recycle a large part of their nutrient supply, it is one of four lakes designated for long-term monitoring by the Water Quality Control Branch. It will be sampled monthly year after year to determine trends in water quality compared to climatic cycles.

TROPHIC CHARACTERISTICS — Ice-free season averages

		1978	1979
PHOSPHORUS	ug/L	101.	144.
NITROGEN	mg/L	2.22	2.24
CHLOROPHYLL	ug/L	38.	27.
SECCHI TRANSPARENCY	m	1.7	2.5
TOTAL NUMBER OF BENTHIC ORGANISMS			7,900/m²
Oligochaeta			48% of total
Chironomidae			34% of total

Explanation of Lake Characteristics

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Drainage Area or the watershed of a lake is the land surface from which a lake receives its water. As rain water or snowmelt gathers in streams, it picks up soil particles, nutrients and other materials and carries them to the lake.

A study of more than 30 Alberta lakes shows that when drainage areas are large compared to lake volumes, (i.e. when this **Drainage Area/Lake Volume** ratio is large), lakes have more algae (are more eutrophic) (see TROPHIC CHARACTERISTICS).

Mean Depth is the volume of the lake divided by the surface area. Shallow lakes are often more eutrophic than deeper lakes of a similar size.

Inflow is the total volume of water entering the lake in a year. It is related to **Residence Time,** which indicates the time it would take the inflow to completely fill an empty lake.

TEMPERATURE

Alberta lakes show two basic annual patterns of temperature distribution through the water.

Deep lakes, or those protected from strong winds, form layers with the coldest water near the bottom. Because this colder water is denser, it resists mixing into the warmer, lighter upper layer.

For much of the summer, the bottom portion of water is isolated from the top portion. In spring and fall, these lakes usually mix from top to bottom from wind action as the water becomes uniform in temperature and density. In winter, under ice, the warmest water (about 4°) is on the bottom, because water is most dense at this temperature.

Shallow lakes mix throughout the summer or layer only temporarily. In winter, the temperature pattern of these lakes is similar to that of deep lakes.

The diagram(s) show temperature at each depth over the annual cycle. Similar temperatures over time are connected by lines called isotherms. Vertical lines indicate mixing, while horizontal lines indicate layering.

DISSOLVED OXYGEN

Oxygen is essential to the life in lakes. It enters the lake water from the air through wind action, and plant photosynthesis.

Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the "health" of a lake by studying its patterns and quantity of oxygen.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen throughout the year at all depths. But as a lake becomes more eutrophic, and increasing quantities of plants and animals respire and decay, the balance shifts toward consumption — especially near the lake bottom where dead organisms accumulate.

In deep productive lakes (see TEMPERATURE), the oxygen in the isolated bottom layer may deplete rapidly, forcing fish to move into the upper layer (Fish are stressed when oxygen falls below about 20% saturation — shown in red on the diagram). Fish kills occur when decomposing or respiring algal populations use up the oxygen. In summer, this usually happens during an algal bloom on calm nights.

The diagram shows oxygen saturation at each depth over the annual cycle. Similar saturations over time are connected by lines called isopleths. Vertical lines indicate uniform saturation from top to bottom, while horizontal lines indicate stagnation near the bottom.

SALINITY AND TOTAL DISSOLVED SOLIDS

Lake water contains a multitude of dissolved substances. These can be seen by allowing a dish of lake water to evaporate. If the water is filtered to remove living organisms and other particles, and then allowed to evaporate, the residue is called **Total Dissolved Solids.**

The ions* that make up most of this residue can be measured individually, giving a value for **Total Salinity** when added together. The **Ionic Diagram** presents all of the major ions in a lake in proportion to each other.

Salinity is controlled by the types of rock or soil in the watershed and by the amount of evaporation relative to precipitation. Lakes of high salinity, such as many of those found in southeastern Alberta, have fewer species of plants and animals than freshwater lakes; many are too saline to support fish.

*Ions: Chemical form in water of constituents such as sodium and carbonate.

PH AND ALKALINITY

The pH of lake water refers to its concentration of hydrogen ions on a scale that runs from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral — neither acidic nor alkaline.

Most Alberta lakes fall between pH 6 to 9, with the majority on the alkaline side. **Alkalinity** refers to the capacity of water to neutralize an acid, and is a measure of the alkaline materials present in the water.

Alberta lakes that were formed in sedimentary bedrock have a large capacity to neutralize acids entering them, such as from acid rain.

TROPHIC CHARACTERISTICS

The word "trophic" literally means nourishment.

Mountain lakes usually are "poorly nourished" or **oligotrophic.** Levels of nutrients such as phosphorus and nitrogen are low, plant life is sparse, and the water is clear. Fish production is low.

On the other end of the scale are well-nourished or fertile lakes called **eutrophic.** In these lakes, aquatic plants, including tiny suspended algae, flourish because the water contains abundant nutrients.

Mesotrophic lakes, those intermediate in fertility, often combine the best features of the other two types.

In some lakes, the nutrient supply is so high that plant growth inhibits the recreational use of the lake. Lake users consider such a lake to have poor water quality. One of the purposes in studying lakes is to determine whether fertility is increasing.

There are several ways to measure a lake's fertility or **Trophic Status.**

Phosphorus and **nitrogen** can be measured directly. Phosphorus in lakes of the Boreal Forest/ Parkland areas of Alberta range between 10 and 120 ug/L, or oligotrophic to highly eutrophic, and nitrogen ranges between 0.5 and 3.5 mg/L.

Transparency declines as a lake becomes more fertile. It is measured with a black and white plate called a **Secchi Disc,** which is lowered through the water on a line marked at metre intervals. The depth at which it can no longer be seen is the Secchi transparency.

The quantity of algae in the water can be determined by measuring its content of **Chlorophyll,** the green photosynthetic pigment.

The number of animals living in the bottom mud of the lake also may indicate its fertility. **Oligochaeta** are tiny worms; **Chironomidae** are immature stages of a fly called a midge.

THEORETICAL PHOSPHORUS SUPPLY

Lake scientists know that for most lakes, the amount of algae in the water is related directly to the amount of phosphorus. This is because phosphorus is usually in shortest supply of all the nutrients that lake plants need. When it runs out, the algal population can no longer increase. A larger phosphorus supply usually results in more algae.

Based on studies from all over North American, the quantity of phosphorus contributed by a hectare of forest is remarkably similar no matter where the lake is located. Similarly, agricultural or cleared land overlying sedimentary bedrock contributes fairly similar quantities of phosphorus per hectare in most lake watersheds. This was confirmed for Alberta by measuring quantities of phosphorus supplied by various land uses in the Baptiste Lake watershed.

In all studies, the phosphorus supply from cleared or agricultural land was greater than that from forest, averaging 5 times more.

The "theoretical" phosphorus supply is estimated, without actually measuring it, by multiplying phosphorus supply factors for each type of land use by the area of that land use.

Similar factors are used for the supply from precipitation. The supply from sewage assumes that all sewage enters the lake, since it is nearly impossible to measure this source in lakes. Therefore, the number reported represents the maximum possible supply from that source.

It might be expected that a large phosphorus supply would produce a eutrophic lake. But the size of the lake is also important. If the total phosphorus supply is divided by the surface area of the lake, the resulting **Areal Loading** figure can be compared with other lakes, and can be used as an indication of trophic status.

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